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ABSTRACT

Many previous studies have documented the importance of time needed for learning and time spent in learning as parameters of educational achievement. However, most of this research has not considered the different types of tasks students are asked to learn. This study examined differences in student learning rates, amount of information acquired, and amount of information retained in three common types of classroom tasks. Reflecting Bloom's (1956) taxonomy, these tasks required knowledge of specific facts; comprehension of basic concepts and principles; or application of facts, concepts, and principles to problem-solving activities. A total of 88 seventh and eighth graders were given five repeated exposures to three reading passages and were tested following each trial. A retention test was administered 1 week later. Results indicated large differences among knowledge, comprehension, and application tasks for all measures of student performance. Two explanations of the results were perceived as relevant to classroom practice: (1) the three different types of tasks may be truly hierarchical in complexity (implying that teachers should allow proportionately more time for students to master complex tasks), or (2) schools may provide less exposure to the comprehension tasks (in which case teachers might rectify the problem by concentrating on these skills). In terms of research design, it was suggested that time differences in mastering these tasks could be minimized by providing corrective feedback. (Author/CB)

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Learning Rate Differences for Knowledge, Comprehension and Application Tasks

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Abstract

Many previous studies have documented the educational relevance of time needed for learning (TTL) and time spent in learning (TSL) as important parameters of student achievement. Most of this research, however, has not considered the different types of tasks students are asked to learn. Using the knowledge, comprehension, and application classifications from Bloom's (1956) taxonomy, this study examined differences in student learning rates (TTL), amount of information acquired, and amount of information retained on three common types of classroom tasks. Large differences were found among knowledge, comprehension, and application tasks for all measures of student performance. These results are discussed in light of their implications for school learning and future TTL research.

Based on Carroll's (1963a) model of school learning, a number of studies have documented the educational relevance of time needed for learning (TTL) and time spent in learning (TSL) as important parameters of student achievement (for reviews, see Berliner, 1979; Borg, 1980; Caldwell, Huitt & Graeber, 1982; Fredrick & Walberg, 1980; Gettinger, in press; Karweit, 1980; Rosenshine & Berliner, 1978). Continued research in this area has produced a number of refinements in Carroll's original model (for example, differentiating the constructs of academic engaged time and academic learning time) and facilitated a variety of educational programming strategies designed to maximize classroom learning (see Bloom, 1976; Cooley & Leinhardt, 1980; Fisher et al., 1978, 1980; Powell, 1980; Wiley & Harnischfeger, 1974). In some cases the two time variables (TTL and TSL) have been strongly correlated with achievement outcomes, while in others the relationship between time and learning has been only minimal. The inconsistency of these findings led Fredrick and Walberg (1980) to conclude that, "time devoted to school learning appears to be a modest predictor of school achievement." (p. 193)

Several sources for these inconsistencies have been identified. Karweit and Slavin (1981, 1982) have pointed to variations in the measurement of TSL as one key factor. They have demonstrated that

using different observational techniques to assess TSL produces varying effects on achievement, even when the same data sets are analyzed. Considering that TSL has been indexed by measures ranging from number of years spent in formal schooling (Harnqvist, 1968, 1977; Hyman, Wright & Reed, 1975) to number of minutes engaged in learning tasks of appropriate difficulty (Fisher et al., 1978, 1980), it is not surprising that studies relating TSL to academic achievement have been inconsistent. Achievement has also been assessed by a number of different outcome measures which creates another source of variance when comparing data across studies.

Gettinger (in press) has noted that many studies focus exclusively on TSL, ignoring TTL which is a critical mediating variable between TSL and achievement. She maintains that it is misleading to consider how much time individual students spend in learning apart from how much time is needed. Since degree of learning is influenced by both TTL and TSL in Carroll's model, studies that relate only one of the time variables to achievement are likely to yield inconsistent results.

Cornbleth (1980), in a critique of the literature on TSL, has argued that the research questions addressed in many studies have remained too global. She suggests that asking the questions, How much time spent on what tasks?, How much time spent on task at what costs?, and How much time spent on task toward what ends?,

may yield more educationally relevant information that repeatedly asking the general question, How much time spent in learning?

A similar criticism may be levelled at TTL research. Although it is well documented that individual learners vary in the amount of time they need to learn classroom tasks (Atkinson, 1968; Bloom, 1974; Carroll, 1963b, 1970; Glaser, 1968; Suppes, 1964; Yeager & Lindvall, 1967), little attention has been paid to the kinds of tasks they are asked to master. That is, TTL researchers have concentrated on the question, How much time needed for learning?, but not inquired, How much time needed for learning what tasks? This has led to a generalized assertion by both Bloom (1974) and Carroll (1970) that approximately 90% of regular classroom students can master school learning tasks within a 5:1 time ratio (3:1 when a mastery learning approach is used consistently, according to Bloom). Empirical evidence is lacking, however, that this is the case for all types of school learning.

Clearly, students in elementary, middle, and high school classrooms are asked to learn a diverse set of curricular tasks. These may be classified not only according to content (i.e. math, science), but also according to type. From the vantage point of Bloom's (1956) taxonomy, three different types of tasks appear with regularity in most school curricula (see Reynolds, note 1). These are: (1) tasks that require knowledge of specific facts, (2) tasks that require comprehension of basic concepts and principles, and

(3) tasks that require application of facts, concepts, and principles to problem-solving activities.[1] Although it is generally agreed that this is the case, past TTL research has failed to differentiate among tasks according to type, focusing instead on differences in learning rate for various subject areas (i.e. math vs. reading). This failure to accurately classify the tasks on which TTL was measured creates yet another source of inconsistency in research on time and learning.

As an initial step in addressing this problem, this study sought to examine learning rate (TTL) differences on tasks requiring knowledge, comprehension, and application. More specifically, the questions were asked: When difficulty level and amount of time exposed to learning materials are controlled, will there be significant differences in the learning rates (TTL) at which students attain mastery of knowledge vs. comprehension vs. application tasks? Will there also be significant differences in the amount of material retained?

Method

Subjects

The subjects participating in this study were 88 seventh and eighth-grade students (48 seventh and 40 eighth) from a small school district (N = 1400) in southern Wisconsin. At the time of investigation all subjects were functioning in the regular classroom. Those students with diagnosed learning handicaps or recent referrals

for suspected handicaps were excluded. The district serves predominantly white students (99%) and is comprised of families from middle to lower-middle class socioeconomic status. The present sample consisted of 87 whites and one Asian pupil. Forty-six males and 42 females participated. The mean age (in months) for the sample was 162.47 (Range = 150-177; SD = 7.19) and the mean IQ from the Henmon-Nelson Tests of Mental Ability (French, Lamke & Nelson, 1973) was 108.51 (Range = 86-136; SD = 10.54). Mean total reading and total battery standard scores from the Stanford Achievement Test (Madden, Gardner, Rudman, Karsen & Merwin, 1973) were 176.52 (Range = 115-235; SD = 18.59) and 176.00 (Range = 146-233); SD = 16.77) respectively.

Instrumentation

Experimental Learning Tasks. Three experimental learning tasks were developed to assess student TTL. The tasks were designed to simulate school learning and consisted of two parts: (1) a fictitious reading passage and (2) a 15-item, multiple-choice criterion test. The three learning passages covered unrelated topics and were 25, 26, and 26 typewritten lines in length (313, 318, and 326 total words per passage). Reading levels for the passages were nearly identical as estimated by the Fry Readability Index (Fry, 1968). All three passages were at a middle seventh-grade reading level according to this measure (M syllables/100 words

= 138; M sentences/100 words = 6). Hence, the passages were equivalent in length and readability.

Each 15-item criterion test was divided into three 5-item sections assessing knowledge, comprehension, and application of passage content. Following each reading passage students were required to answer five questions demonstrating knowledge of specific facts, five questions demonstrating comprehension of basic concepts and principles, and five questions demonstrating application of the material to problem-solving situations. Total scores for each of the three classes of learning were obtained by summing across passages and with classes such that 15 total items were possible for knowledge, comprehension, and application respectively. This procedure ensured that reading passages were fully crossed with learning classes and guarded against passage-specific effects influencing students' scores. These summary scores (number of items correct out of 15) for knowledge, comprehension, and application were obtained for each subject on five successive trials at attaining mastery.

The items on the three criterion tests were initially developed by the authors. Only items on which 100% agreement was reached as to which class of learning they represented were retained for potential field testing in the pilot study. As a second check on the representativeness of the items, three independent raters were trained in Bloom's criteria for classifying knowledge, comprehension,

and application items. Again, only those items with 100% agreement among the raters were retained for further testing in the pilot study. Finally, two seventh and two eighth-grade teachers reviewed and edited all three reading passages and provided feedback concerning the difficulty of test items.

Procedure

TTL and Mastery Defined. TTL has been defined in a variety of ways ranging from elapsed time in weeks, months, and years to engaged time in minutes. In the present study, a more controlled measure of TTL was used. TTL was defined as the number of trials needed by individual subjects to attain criterion performance on each of the learning tasks. All subjects were given five repeated exposures to three reading passages and following each trial were tested for knowledge, comprehension, and application. Three TTL scores (one each for knowledge, comprehension, and application) were determined for each subject as the initial trial on which criterion was achieved. Criterion performance was defined as answering 13 of 15 questions correctly (approximately 87%) for each class of school learning.

Pilot Study. The purpose of the pilot study was to set the difficulty levels of the three criterion tests for knowledge, comprehension, and application to as near equivalency as possible. Approximately 40 items were written for each of the three classes

of learning, from which 15 were finally selected for use on the three criterion tests. The p-values of all items were examined and initially accepted if in the range of difficulty from .40 to .85. The best 15 items were then selected on the basis of covering nonoverlapping content and averaging to a mean p-value between .65 and .70.

An initial subject pool of 176 seventh and eighth-grade students was established for this study. Of this number, 68 students (34 seventh and 34 eighth) were randomly selected for participation in the pilot study. Pilot subjects were exposed to the three reading passages in the same manner as used in the main study (but for one trial only) and then required to respond to all items developed for field testing.

Final results of the pilot study yielded 15 knowledge items with a mean p-value of .69 (Range = .42-.85), 15 comprehension items with a mean p-value of .67 (Range = .43-.83), and 15 application items with a mean p-value of .66 (Range = .42-.83). A series of pairwise t tests yielded no significant differences between mean difficulty of knowledge and comprehension items (t (14) = 1.81; $p > .05$), knowledge and application items (t (14) = 2.08; $p > .05$), and comprehension and application items (t (14) = 0.60; $p > .05$).

Main Study. The authors and one trained researcher implemented the main study. The 88 subjects were randomly assigned to one of nine groups consisting of nine or ten students each. Each of the

three researchers was then randomly assigned to three groups and presented the three learning tasks during a single school week. Order of passage presentation was also determined by random assignment for each of the nine groups.

The procedure for each learning task was identical. The reading passage and five forms of the criterion test were distributed face down. Subjects were then given a brief set of instructions. They were instructed to turn over the passage and follow along at their desks as it was read aloud.[2] After the passage had been read, it was turned face down and the first of five criterion tests was read aloud, item-by-item. Subjects followed along at their desks and circled one of four responses to each question on a typed answer sheet. After all responses had been registered, the subjects were again instructed to turn over their reading passages and follow along as the passage was read a second time. Following this, a second criterion test with identical items, but in a different order, was taken.[3] This procedure was repeated an additional three times making the total number of exposures to the passage materials five. At the conclusion of the final trial subjects were given group corrective feedback on their responses.

Scoring of the criterion tests was accomplished with the aid of scoring templates. As a check on the accuracy of scoring, 15 sets of criterion tests for each reading passage (45 total) were randomly selected and scored by an independent rater. No scoring

errors were detected.

Exactly five days after the final learning task was completed, all subjects were asked to take a retention test (participants had not been instructed to try and retain the materials for a future test). The test contained the identical 45 items from the three criterion tests used during the previous week. Items were read aloud, as in the initial phase of the study, and subjects again circled their responses on a typewritten answer sheet. The passages themselves were not read prior to the retention test and subjects took the test only one time. Three retention scores were determined for each subject as the number of correct responses given for each of the three classes of learning. Of the original 88 subjects participating in the study, 75 took the retention test.

Data Analysis

The major research question of this study concerning differences in TTL among knowledge, comprehension, and application tasks was addressed by an analysis of covariance (ANCOVA) for repeated measures.[4] Three important sets of data were analyzed in this fashion. These were: (1) differences between mean number of correct responses for knowledge, comprehension, and application items on each of learning trials 2, 3, 4, and 5, (2) differences in the mean gain from trial 1 to trial 5 among knowledge, comprehension, and application, and (3) differences in the mean TTL scores determined

for subjects on knowledge, comprehension, and application tasks.

The related question concerning differences in amount of material retained for each of the three classes of learning was also addressed by an ANCOVA for repeated measures. Finally, Newman-Keuls post hoc analyses were performed to assess differences between knowledge-comprehension, knowledge-application, and comprehension-application comparisons on all measures.

Results

Item Difficulty. The mean difficulty levels and ranges of item difficulty for the 88 subjects in the main study were similar to those obtained in the pilot. The mean p-value for knowledge items was .69 (Range = .41-.87), while the mean p-values for comprehension and application items were .66 (Range = .45-.87) and .66 (Range = .40-.82) respectively.

Descriptive Statistics. Table 1 provides means, standard deviations, and ranges for the various measures of initial student performance on the three learning tasks and retention of the materials five days later. It is noteworthy that a consistent

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Insert Table 1 about here

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pattern can be observed across all four measures of student performance. Individual trial scores, gain scores, TTL scores (trial on which mastery was attained), and retention scores all indicate that

knowledge materials were learned and remembered with greater ease than either comprehension or application materials. Similarly, subject performance on the comprehension measure was superior in all respects to performance on the application measure. This trend toward decreased speed and depth of mastery from knowledge to comprehension to application tasks is consistent with the theory underlying Bloom's taxonomy of educational objectives. Since it is posited that each class of learning in the taxonomy is more complex than the previous one(s), it is not surprising that subjects in this study needed more time to attain mastery as the learning tasks advanced up the hierarchy.

This trend is further supported by the fact that 78 subjects (89%) reached mastery by trial 5 on the 15 knowledge items, but only 58 (66%) achieved mastery by trial 5 for comprehension and 30 (34%) for application. This difference in the proportion of subjects attaining mastery by trial 5 on the three criterion tests is significant ($X^2(2) = 56.38$; $p < .001$). Bloom's (1974) claim that 90% of learners can reach mastery within a 5:1 time ratio may need to be qualified according to these results.

These data pertaining to individual trial scores, gain scores, TTL scores, and retention scores were also broken down by grade and sex. A series of one-way ANOVAs performed separately for each variable included in Table 1 yielded no significant grade or sex differences for any of the performance measures.

Analyses of Covariance. As noted, one-way ANCOVAs for repeated measures were used to address the major research questions due to an unanticipated difference in subjects' trial 1 performance. As shown in Table 1, trial 1 performance for knowledge yielded a mean of 10.43 items correct, while trial 1 performance for comprehension and application resulted in means of 9.91 and 9.78 items correct respectively. When analyzed using a one-way ANOVA for repeated measures, the difference among the three means was significant (F (2,173) = 4.64; $p < .05$). Hence, in order to preserve the important assumption that subjects began each of the three learning tasks at comparable levels, trial 1 performance was covaried with subsequent individual trial scores, gain scores, TTL scores, and retention scores.

Table 2 provides a summary of original means, adjusted means, and F statistics obtained from the ANCOVAs for the four measures of student performance analyzed. As can be seen, the differences in

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Insert Table 2 about here

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student performance on knowledge, comprehension, and application tasks are highly significant for all measures. This includes large differences for each of learning trials 2 (F (2,173) = 36.43; $p <$ .001), 3 (F (2,173) = 71.76; $p < .001$), 4 (F (2,173) = 69.56; $p <$ .001), and 5 (F (2,173) = 68.99; $p < .001$) as well as for total gain from trial 1 to trial 5 (F (2,173) = 68.99; $p < .001$) and

trial on which mastery (TTL) was attained (F (2,173) = 54.22; $p <$ .001).[5] These data all bear on the major research question of this study and clearly support the conclusion that differences exist in the rates at which students attain mastery of knowledge, comprehension, and application tasks. Separate ANCOVA summary tables for each of these analyses are provided in Tables 3 through 8.

Insert Tables 3 through 8 about here

The ANCOVA performed on retention scores indicated that the amount of passage material retained five days after the final learning session was also significantly different among the three classes of learning (F (2,147) = 12.89; $p < .001$). The summary statistics for this analysis are shown in Table 9.

Insert Table 9 about here

Newman-Keuls post hoc comparisons on the adjusted means were performed to determine whether significant differences occurred between knowledge and comprehension (K-C), knowledge and application (K-A), and comprehension and application (C-A) on each of the above measures. Beginning with trial 2 performance, significant differences were found for K-C ($p < .01$), K-A ($p < .01$), and C-A ($p < .01$) comparisons. That is, subjects performed significantly better on knowledge items than either comprehension or application items and significantly better on comprehension than application

items for learning trial 2. Similar results were obtained for each of learning trials 3, 4, and 5 with all comparisons significant ($p < .01$) in favor of knowledge in comparison with comprehension and application and comprehension in comparison to application. The same pattern was also obtained for all comparisons of gain scores and TTL scores ($p < .01$). Hence, subjects in this study attained mastery at a faster rate and acquired more information on knowledge tasks than either comprehension or application tasks. The same was true of comprehension tasks in comparison to application tasks.

The only measure which deviated somewhat from this pattern was retention scores. On this measure, the K-A and C-A comparisons were significant ($p < .01$) but the K-C comparison was not. Subjects retained about the same amount of knowledge and comprehension material, but significantly more of each in comparison with application. These Newman-Keuls results are summarized in Table 10.

Insert Table 10 about here

Discussion

A number of explanations might be offered to account for the differences in student performance on knowledge, comprehension, and application tasks obtained in this study. Two of these are particularly germane to classroom learning. First, it appears that

the three different types of tasks were truly hierarchical in complexity. Hence, the intellectual demands of the tasks were such that increasing levels of cognitive skill were needed to attain mastery. This of course is Bloom's original contention. In delineating the taxonomy he noted that knowledge tasks demand only direct recall or recognition of factual materials, whereas comprehension tasks require at least translation of the materials from one form to another and may also involve extrapolation or interpolation of information. Application tasks require the additional skills of identifying and selecting the appropriate pieces of information needed to solve new problems. That tasks requiring such different degrees of cognitive skill should result in different rates of learning does not seem surprising. Nor is it surprising that increasingly less information was mastered as the tasks advanced up the hierarchy.

Alternatively, it is possible that the obtained differences in student learning rates are attributable to differential exposure to the three types of tasks. That is, schools may provide an optimum of experience with knowledge tasks but increasingly less exposure to comprehension and application tasks. Under these conditions students would likely become efficient learners of knowledge tasks with routinized strategies for the mastery of this kind of information, but remain less efficient at mastering tasks to which they have not been equally exposed.

Deciding which one of these explanations is more plausible was not the focus of this study. Both have merit and it appears likely that some combination of the two factors may underlie the differences obtained. Both also carry clear implications for classroom instruction. In general, students need more time to attain mastery of school learning tasks as they advance up the hierarchy of Bloom's taxonomy. Allocating similar amounts of time to master units of instruction (or more likely items within units of instruction) that require largely knowledge vs. comprehension vs. application skills may be inviting failure and frustration for many students. The results of this study indicate that most regular classroom students (89%) can master knowledge tasks within a 5:1 time ratio, but only about two-thirds reach mastery on comprehension tasks and one-third on application tasks in a similar amount of time. Revised estimates of TTL are needed for tasks beyong the knowledge classification under traditional learning conditions.

It would also be well for schools to examine the differential exposure hypothesis. It appears from this study that by the time regular classroom students reach seventh grade they have developed efficient strategies for acquiring knowledge information. They are less efficient at mastering comprehension and application tasks. If a part of the reason for this reduced efficiency is less time spent on comprehension and application tasks, classroom teachers might rectify the problem by concentrating more heavily on these

skills. Tentatively, it appears that increased time could at least be spent teaching students the strategies they need for acquiring these kinds of information since they do not necessarily learn them independently.

This raises one final issue in dealing effectively with learning rate differences for knowledge, comprehension, and application tasks. Corrective feedback, an integral component of mastery learning, was not provided in this study between successive learning trials. It would be useful to know if such feedback would accelerate learning rates for each of the three tasks, as mastery researchers have found when examining school learning in general. If so, perhaps time differences in mastering the three types of tasks could be minimized.

Footnotes

1. It is less clear how well or extensively analysis, synthesis, and evaluation tasks are dealt with in elementary and secondary level classrooms. Hence, they were not considered in this study.
2. Passages were read aloud both to minimize reading errors that might be committed by individual subjects and to standardize the amount of time students were exposed to each set of materials. Although tape-recorded readings would have provided optimal control in this sense, a closer approximation to group instruction in the classroom was desired. During the training sessions, the three researchers consistently read the passages within five seconds of one-and-one-half minutes.
3. Although item order was determined randomly for each successive presentation of criterion tests, items were always presented by class of learning. That is, the five knowledge items were always clustered together, though in a randomly different order each time. Similarly, the five comprehension and application items on each criterion test were always clustered together, but in a randomly different order for each presentation.
4. ANCOVAs, rather than ANOVAs, were needed because an unanticipated difference in subjects' trial one performance occurred. Performance on knowledge items was significantly higher ($F(2,173) = 4.64$; $p < .05$) than on comprehension and application

items.

5. This difference is probably larger than here reported. When subjects failed to attain mastery by trial five for knowledge, comprehension, or application they were arbitrarily assigned a TTL score of six for that class of learning. The trial on which a subject actually reached mastery for that class of learning would likely have been higher. Considering that only 34% of the subjects reached mastery by trial five for application (compared with 66% for comprehension and 89% for knowledge), a strong possibility exists that more subjects were falsely assigned TTL scores of six for this category than for knowledge or comprehension. This would have the effect of underestimating the ~~time~~ true difference among the three kinds of tasks.

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Table 1

Descriptive Statistics for All Subjects on

Individual Trial Scores, Gain Scores,

TTL Scores, and Retention Scores

Variable	Mean	SD	Range
Trial 1 - Knowledge	10.43	2.16	3 - 14
Trial 1 - Comprehension	9.91	2.46	5 - 15
Trial 1 - Application	9.78	2.38	2 - 15
Trial 2 - Knowledge	12.52	1.84	6 - 15
Trial 2 - Comprehension	11.49	2.25	4 - 15
Trial 2 - Application	10.26	2.29	3 - 15
Trial 3 - Knowledge	13.30	1.43	9 - 15
Trial 3 - Comprehension	11.84	2.12	5 - 15
Trial 3 - Application	10.61	2.09	3 - 15
Trial 4 - Knowledge	13.49	1.37	8 - 15
Trial 4 - Comprehension	12.18	2.18	5 - 15
Trial 4 - Application	10.73	2.09	2 - 15
Trial 5 - Knowledge	13.66	1.48	6 - 15
Trial 5 - Comprehension	12.38	2.12	4 - 15
Trial 5 - Application	10.90	2.27	2 - 15
Trial 1-2 Gain - Knowledge	1.99	1.80	-3 - 6
Trial 1-2 Gain - Comprehension	1.58	1.78	-3 - 7
Trial 1-2 Gain - Application	0.48	1.78	-3 - 5
Trial 2-3 Gain - Knowledge	0.77	1.07	-1 - 5
Trial 2-3 Gain - Comprehension	0.35	1.25	-3 - 5
Trial 2-3 Gain - Application	0.35	1.23	-3 - 3
Trial 3-4 Gain - Knowledge	0.19	0.80	-2 - 3
Trial 3-4 Gain - Comprehension	0.34	1.03	-3 - 4
Trial 3-4 Gain - Application	0.11	0.94	-3 - 3
Trial 4-5 Gain - Knowledge	0.17	0.78	-2 - 3
Trial 4-5 Gain - Comprehension	0.19	1.09	-4 - 4
Trial 4-5 Gain - Application	0.17	1.00	-3 - 3

Table 1 (Continued)

Variable	Mean	SD	Range
Grand Gain - Knowledge	3.13	0.20	-2 - 8
Grand Gain - Comprehension	2.47	0.24	-2 - 8
Grand Gain - Application	1.11	0.23	-4 - 6
TTL Score - Knowledge	2.61	1.51	1 - 6
TTL Score - Comprehension	3.75	1.93	1 - 6
TTL Score - Application	4.89	1.81	1 - 6
Retention Score - Knowledge	13.44	1.77	7 - 15
Retention Score - Comprehension	12.89	1.99	5 - 15
Retention Score - Application	12.13	2.22	2 - 15

Table 2

Original Means, Adjusted Means, and F-Statistics for Individual Trial Scores, Gain Scores, TTL Scores, and Retention Scores

Variable	Original Mean	Adjusted Mean	F
Trial 2 - Knowledge	12.52	12.24	
Trial 2 - Comprehension	11.49	11.59	35.43***
Trial 2 - Application	10.26	10.44	
Trial 3 - Knowledge	13.30	13.08	
Trial 3 - Comprehension	11.84	11.92	71.76***
Trial 3 - Application	10.61	10.75	
Trial 4 - Knowledge	13.49	13.29	
Trial 4 - Comprehension	12.18	12.25	69.56***
Trial 4 - Application	10.73	10.85	
Trial 5 - Knowledge	13.66	13.47	
Trial 5 - Comprehension	12.38	12.44	68.99***
Trial 5 - Application	10.90	11.02	
Grand Gain - Knowledge	3.13	3.39	
Grand Gain - Comprehension	2.47	2.37	68.99***
Grand Gain - Application	1.11	0.94	
TTL Score - Knowledge	2.61	2.83	
TTL Score - Comprehension	3.75	3.67	45.22***
TTL Score - Application	4.89	4.75	
Retention Score - Knowledge	13.44	13.28	
Retention Score - Comprehension	12.89	12.95	12.89***
Retention Score - Application	12.13	12.23	

***$p < .001$

Table 3

Repeated Measures ANCOVA Summary Table for Differences in Trial 2 Performance for Knowledge, Comprehension, and Application

Sources	df	SS	MS	F
Trial 2 Scores	2	150.05	75.02	36.43***
Trial 1 Scores - Covariate	1	148.84	148.84	
Error	173	356.28	2.06	

***$p < .001$

Table 4

Repeated Measures ANCOVA Summary Table for Differences in Trial 3 Performance for Knowledge, Comprehension, and Application

Sources	df	SS	MS	F
Trial 3 Scores	2	241.48	120.74	71.76***
Trial 1 Scores - Covariate	1	77.04	77.04	
Error	173	291.08	1.68	

***$p < .001$

Table 5

Repeated Measures ANCOVA Summary Table for Differences in Trial 4 Performance for Knowledge, Comprehension, and Application

Sources	df	SS	MS	F
Trial 4 Scores	2	265.69	132.85	69.56***
Trial 1 Scores - Covariate	1	63.12	63.12	
Error	173	330.39	1.91	

***$p < .001$

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Table 6

Repeated Measures ANCOVA Summary Table for Differences in Trial 5 Performance for Knowledge, Comprehension, and Application

Sources	df	SS	MS	F
Trial 5 Scores	2	269.01	134.50	68.99***
Trial 1 Scores - Covariate	1	56.64	56.64	
Error	173	337.31	1.95	

***$p < .001$

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Table 7

Repeated Measures ANCOVA Summary Table for Differences in Total Gain for Knowledge, Comprehension, and Application

Sources	df	SS	MS	F
Grand Gain Scores	2	269.01	134.50	68.99***
Trial 1 Scores - Covariate	1	241.64	241.64	
Error	173	337.31	1.95	

***$p < .001$

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Table 8

Repeated Measures Summary Table for Differences in TTL Scores for Knowledge, Comprehension, and Application

Sources	df	SS	MS	F
TTL Scores	2	157.63	78.81	45.22***
Trial 1 Scores - Covariate	1	111.86	111.86	
Error	173	301.54	1.74	

***$p < .001$

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Table 9

Repeated Measures ANCOVA Summary Table for Differences in Retention Scores for Knowledge, Comprehension and Application

Sources	df	SS	MS	F
Retention Scores	2	48.84	24.42	12.89***
Trial 1 Scores - Covariate	1	12.32	12.32	
Error	147	278.42	1.89	

***$p < .001$

Table 10

Summary Table for Newman-Keuls Post Hoc Comparisons

Comparison	df	Critical Value	Obtained Value
Trial 2 (K-C)	2,173	48.99	57.2**
Trial 2 (K-A)	3,173	55.46	158.4**
Trial 2 (C-A)	2,173	48.99	101.2**
Trial 3 (K-C)	2,173	44.26	102.12**
Trial 3 (K-A)	3,173	50.10	205.08**
Trial 3 (C-A)	2,173	44.26	102.96**
Trial 4 (K-C)	2,173	47.17	91.52**
Trial 4 (K-A)	3,173	53.40	214.72**
Trial 4 (C-A)	2,173	47.17	123.20**
Trial 5 (K-C)	2,173	47.68	86.64**
Trial 5 (K-A)	3,173	53.97	215.60**
Trial 5 (C-A)	2,173	47.68	128.96**
Grand Gain (K-C)	2,173	47.68	89.76**
Grand Gain (K-A)	3,173	53.97	215.60**
Grand Gain (C-A)	2,173	47.68	125.84**
TTL (K-C)	2,173	45.03	95.04**
TTL (K-A)	3,173	50.96	168.96**
TTL (C-A)	2,173	45.03	73.92**
Retention (K-C)	2,173	43.35	24.75
Retention (K-A)	3,173	49.10	78.75**
Retention (C-A)	2,173	43.35	54.00**

**$p < .01$

Table 9

Repeated Measures ANCOVA Summary Table for Differences in Retention Scores for Knowledge, Comprehension and Application

Sources	df	SS	MS	F
Retention Scores	2	48.84	24.42	12.89***
Trial 1 Scores - Covariate	1	12.32	12.32	
Error	147	278.42	1.89	

***$p < .001$

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Comparison	df	Critical Value	Obtained Value
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Trial 2 (K-A)	3,173	55.46	158.4**
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Grand Gain (C-A)	2,173	47.68	125.84**
TTL (K-C)	2,173	45.03	95.04**
TTL (K-A)	3,173	50.96	168.96**
TTL (C-A)	2,173	45.03	73.92**
Retention (K-C)	2,173	43.35	24.75
Retention (K-A)	3,173	49.10	78.75**
Retention (C-A)	2,173	43.35	54.00**

**$p < .01$

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